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ABSTRACT

This paper focuses on the scientific dialogue of a small group following an experiment on motion under gravity. This research was designed to investigate ways in which practical activities can be used to foster links between upper elementary children's spontaneous concepts and Newtonian mechanics. Implicit in this is the notion that teaching consists of inducting children into specific communities that share ways of acting, speaking, and representing objects and experiences. Interactions within a small group of Year 6 children were captured by a video camera and closely examined as to their place within scientific discourse. Initially the interactions had been thought of as discussion, a term used to describe the majority of verbal interactions between students and teachers. The current analysis attempts to uncover the ecology of the group's discussion or the set of rules by which interactions are governed within the group. The conclusions are presented as evidence for describing the group as engaging in scientific dialogue and for inferring solutions to the pedagogical issues raised by this video episode. Key pedagogical issues include "How does dialogue differ from discussion?" and "What sort of environment is necessary for dialogue to occur?" Contains 22 references. (Author/PVD)

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What makes scientific dialogue possible in the classroom?

Brian Doig

The Australian Council for Educational Research

A paper from the symposium presented at the

Annual Meeting of the American Educational Research Association

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What makes scientific dialogue possible in the classroom?

Brian Doig

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Abstract

The focus of this paper is on scientific dialogue following a small group's experiment on motion under gravity. The interactions within the group were captured by a video-camera and later closely examined as to their place within scientific discourse. The nature and ecology of the group members' interactions are presented as evidence for describing the group as engaging in scientific dialogue and for inferring solutions to the pedagogical issues raised by this video episode. Two key pedagogical issues are 'How does dialogue differ from discussion?' and 'What sort of environment is necessary for dialogue to occur?'

Introduction

This paper formed one of three at a symposium presented at AERA in Chicago in 1997. The three symposium papers arose from collaborative research which was carried out by the Australian Research Council funded project *Practical Mechanics in Primary Mathematics* and the *Mechanics in Action Project* at the University of Manchester in the United Kingdom. The research is designed to investigate ways in which practical activities can be used to foster links between upper elementary children's spontaneous concepts and Newtonian mechanics. Implicit in this is the notion that 'teaching consists of inducting children into particular communities that have shared ways of acting, speaking, and representing objects and experiences' (Renshaw 1996: 75). As part of this research, we have been investigating the rôle of small group interactions in supporting children's theory building as we are well aware that 'the importance of establishing communication on the basis of shared experience is without question' (Edwards and Mercer, 1987: 6).

As part of this work, the rôle of dialogue in supporting children's theory building has been investigated. A video-tape recorded in the UK, showing one of the researchers, Julian Williams, working with a small group of Year 6 children, contains a segment which is regarded as exemplifying some of the characteristics of scientific dialogue that many would like to see occur in classrooms.

In Australia, we have been working with a group of Year 5 and 6 teachers, using a program of practical activities which had been developed. Although results, in general, have been very encouraging, it was extremely difficult to achieve genuine dialogue (as opposed to discussion) in the project classrooms. This was despite the fact that this video-taped episode was enthusiastically received by project teachers when it was discussed in some detail early in their involvement in the project. Thus, while the video-taped episode shows a small group of children working with a researcher, a situation which is unlike a classroom in many respects, the question of the extent to which similar dialogue is possible in a classroom is of interest to anyone involved in learning and teaching.

In the AERA symposium the video-taped episode was analyzed from three different perspectives: progress in terms of the science and mathematics, reported by Susie Groves as *Making progress through scientific dialogue*; the evidence for children's learning, together with the teacher's rôle in the process reported as *Scientific dialogue as evidence of learning* by Julian Williams; and what might constitute an enabling environment for a scientific dialogue, which is the substance of the present paper.

Initially the interactions within the episode had been thought of as discussion, a term loosely used within the education community to describe the majority of verbal interactions between pupils and teachers. The analysis from this perspective is an attempt to uncover the ecology of the group's discussion. In this sense, the ecology for social interactions is the set of 'rules' by which interactions are governed within the group (society). The research agenda had included such uncovering in order to inform teachers how they might better foster effective learning through discussion based on shared experiences. What were sought were examples of discussions that showed clearly *how* they worked; in other words the ecology that maintained effective discussion. The analysis attempts to draw on work which examines the nature of dialogue in a range of disciplines, including not only science and mathematics, but also language and philosophy, in order to focus attention on what constitutes scientific dialogue and the means by which it can be implemented in the classroom.

However even at first viewing it became obvious that the talk within the group was in some way different in nature to that which we had seen before. Our curiosity was aroused and it became necessary to explore the interactions in the episode to understand how and why it differed. This exploration was cut short by a colleague, whose field of expertise is philosophy for children, who was asked to comment upon what was happening in the episode. His reaction was immediate: what we had on the video-tape, he claimed, was an example of a philosophical dialogue! And it was a fact that what we saw on screen was qualitatively different from other classroom discussions we had seen.

The context for the video-taped episode

The video-taped episode shows a group of four Year 6 children, Stephanie, Kelly,

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Daniel and Richard, discussing the outcome of a practical activity using a timer-ball, a baseball containing a stopwatch, that allows the time the ball is in flight to be measured to the nearest hundredth of a second.

The group had been asked to find the height from which to drop the timer-ball so that it would take half a second to fall to the ground, after which they would usually have been asked to predict and find the height required for a drop of one second. On this occasion however, after the children found the height for half a second, for some reason they then found the height from which they got a consistent reading of 0.43 seconds, which was 95 cm. They were then asked to find the height for which the time would be exactly double, that is 0.86 seconds. As might be expected, they predicted that this would be double the original height, 190 cm. However, when the ball was dropped the fall took only 0.63 seconds, a surprise for the children.

The girls, Stephanie and Kelly, had done most of the measuring. Daniel was so surprised that the time from 95 cm was only 0.63 seconds that he insisted on trying this several times himself to check. He had some difficulties producing consistent times when dropping the ball as he was holding the ball for a 'pause' before letting go.

For the purpose of this analysis, it is assumed that the problem that is being addressed by the children is that of finding an explanation for their observed data. The video-taped episode that is the subject of this analysis begins at the point where Julian (the researcher) summarises the activity and asks for possible explanations for the data obtained. Richard has just suggested that the timer-ball has gone round a full ten seconds and gone back to zero (there are only three digits available on the display). However he immediately realises that this is wrong, as the fall doesn't take ten seconds.

Types of educational interaction

The introduction of the notion of dialogue had created a dilemma in that the talk that we thought of as 'discussion' now had been differently sited within educational discourse. In order to clarify the distinctions that we believe are critical between types of interactions, both for our own understanding of the video-taped episode and for informing others, particularly teachers, it is necessary to examine each type, particularly in terms of the operational definitions that could be used in classrooms.

We believe with Cazden (1988: 54) that '[c]lassrooms are complex social systems for many reasons, not the least of which are the many different purposes of talk' and with Edwards and Mercer's (1987: 45) view that 'classroom talk has special properties that distinguish it from talk in other setting'. This 'talk' constitutes a particular form of discourse, generally defined as classroom discourse, where 'discourses are forms of language which are generated by the language practices

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of a group of people with shared interests and purposes' (Mercer 1995: 81). Renshaw's definition of the purpose of teaching (1996) quoted above, provides a reason for the distinction between classroom and other types of discourse in Mercer's terms. One would be inclined to think, then, that in classrooms, there is *a* discourse, and that children who are engaged in communicating about matters scientific are engaged in scientific discourse. This view however is somewhat simplistic. Within the classroom there are at least two distinguishable sub-discourses; the first is that of the children and the second that of the teacher. Children's discourse can be classified as everyday, while the teacher's is (in Mercer's terms) educated. Mercer (1995) stresses that the teacher is a discourse guide, whose rôle in science is to help children become fluent in the educated discourse of science, and thus become part of the wider scientific community.

It is clear that under this definition of discourse is included not only written and oral language, but also practices and belief systems. The focus of this paper, however, is not on this broader canvas of discourse, but on the narrower, more focused interactions of pupils and teachers in situations where points of view are debated. There appear to be several terms generally used synonymously; these are conversation, discussion, and dialogue. I wish to look at each of these, distinguish between them, and finally suggest that the interactions that occur in the video-taped episode form a scientific dialogue.

While talking in generalities, I shall use the term 'talk' to describe the discourse; for more specific forms of talk the most appropriate term, conversation, discussion, or dialogue, will be used.

Teasing out the threads of classroom talk

Suggestions for analysing classroom talk are plentiful, although a common thread is the definition of a 'unit' for segmenting the talk into comprehensible chunks. The relationship between these units then forms the basis for interpreting the structure of the dialogue. The best-known of these techniques is the Initiate-Respond-Evaluate cycle, probably because of its prevalence in classroom discussions (Perrott, 1988).

A similar technique is that proposed by Tennenberg (1988). Tennenberg (1988) describes his approach using language arts lessons. He suggests that the sequence of question followed by answer is inadequate as the unit of analysis, and instead uses a larger unit that consists of the teacher soliciting an answer, followed by a student response, a teacher reaction, a further solicit linked to the previous one, with a response and reaction. This sequence of two closely linked questions ('solicits') formed the unit of analysis for his work. Other structures were defined that also formed larger units of analysis than the conventional question/answer unit. Such forms of analysis while useful in some contexts, do not necessarily reveal the underlying ecology of the 'talk'.

As an alternative Mercer (1995) proposed three forms of talk that can be used to aid the analysis of classroom talk and thinking. These forms focus on the type of interactions evident. *Disputational talk* features disagreement and individualised decision making, with few attempts at synthesis. In *cumulative talk* speakers build positively on previous speakers' utterances, but these are used uncritically. *Exploratory talk* on the other hand, contains critical but constructive use of another's ideas; challenges are justified and alternative explanations offered. Further, Mercer (1995: 104) claims that in exploratory talk *'knowledge is made more publicly accountable* and *reasoning is more visible in the talk'* (italics in the original).

Mercer's technique, although for groups of children without a teacher present, appeared the most suitable for determining the ecology of the video-taped episode; it seeks to discover the ways in which the various threads are linked and interwoven to form the whole fabric. However, while recognizing the value of his taxonomy, the reaction of our philosopher colleague (that the video-taped episode showed a philosophical dialogue) swayed us into considering a parallel to Mercer's technique. This was, of course, to consider the conditions for dialogue, such as those suggested by Lipman, Sharp and Oscanyon (1980); these provide 'rules' for teacher behaviour that are thought to be effective in producing dialogue for 'Philosophy for Children'.

Before looking in detail at the ecology of a dialogue, it necessary to be clear in our own minds what the ecology of the other forms of classroom talk are like in practice. Any observer of classrooms would agree that classrooms are dominated by teacher talk, so much so that Powney and McPake (1996) question whether teachers and pupils can have real conversations even in the everyday sense where there is a genuine exchange of ideas. The implication here is that in conversation there is some equality between the participants, and as in Mercer's definition of discourse, some shared interest or purpose. Powney and McPake further comment that 'teachers seem reluctant to listen to pupils' own ideas except to reinforce their own agenda' and that '[p]upils are not engaged in conversation so much as a series of slightly related comments' (p. 4). Unlike social conversations, in classrooms 'teachers have the right to speak at any time and to any person ... interrupt any speaker ... in any volume or tone of voice' (Cazden, 1988: 54).

Implicit in Powney and McPake's view of conversation is freedom from a structure, the capacity to accommodate differences, and the capability to maintain a focus on a topic. In the classroom debate between pupils is not encouraged, but rather teachers make efforts to conciliate, again the antithesis of a hallmark of conversation – the exchange of ideas or viewpoints between parties on a topic of mutual interest.

Discussion has always been considered a feature of 'good' science teaching. In its report on the teaching of science in secondary schools in Great Britain, the Joint Committee of the Incorporated Association of Assistant Science Masters'

Association states that 'discussion reveals the variety in the approach of different minds to the same subject matter ... Initiative is mainly with the pupils while the teacher seeks to direct and stimulate' (Joint Committee of the Incorporated Association of Assistant Science Masters' Association, 1947: 162). Nearly fifty years later the American Association for the Advancement of Science (AAAS, 1996) in it's science education reform program, Project 2061, calls for an emphasis *inter alia* on students being able to communicate effectively on scientific ideas.

However, discussion in science lessons, according to Hofstein and Walberg (1995), consists of teachers asking low-level factual questions and students responding. Not only is this teacher-centred but it involves mainly lecturing and recitation (Hofstein & Walberg, 1995). Edwards and Mercer (1987: 45) claim that 'classroom discourse has properties such as the Initiation-Response-Feedback cycle and that participants must understand that teachers ask questions, teachers know the answers and repeating a question means the answer was wrong'.

That this Initiation-Response-Feedback cycle is seen as 'discussion' by many teachers is clear from the following examples. Powney and McPake (1996) report, based on their observations in classrooms, that although '[teachers] may call a session or part of a session 'discussion' , this often means that a teacher chooses a topic and decides who is to speak' (p. 4). This echoes the view of Perrott (1988) who observed 'the teacher indicates, by her response to the pupils' answers, that the conclusion she wishes the "discussion" to reach has to do with *friends*' (p. 62). This is an affirmation of Cazden's (1988) cycle of teacher initiation, nominated child responding, and the teacher commenting before calling the next child (p. 29).

Although suggestions for improving classroom discussion abound (see, for example, Baird & Northfield, 1992; Elliott, 1996; Jones, 1996) discussion as practised by many classroom teachers is neither synonymous with conversation, nor, I believe, with dialogue, and I wish to maintain the distinction between the terms.

Whilst elements of each of conversation and discussion are evident within the video-taped episode, neither label adequately addresses how, on a single viewing, colleagues were impelled to comment that this episode was an example of dialogue, rather than discussion. How then, is dialogue distinguished from other forms of classroom talk? It is by its enabling environment, or ecology as we have termed it, that a dialogue is marked, where in our sense, the ecology for social interactions are the 'rules' by which the interactions or behaviours are governed within the society.

For Wood and Yackel dialogue exists when there is a symmetric pattern of communication. This symmetry 'exists only when unlimited interchangeability of dialogue roles constitute part of the conditions of interaction' (Wood &

Yackel, 1990: 245). While not disputing this as another possible view of dialogue, as a guide for informing practitioners, it appeared to offer little.

The operational definitions employed to examine the video-taped episode from this perspective were those developed by Lipman *et al* (1980). They describe the hallmarks of a philosophical dialogue in the classroom from the perspective of the rôle of the teacher: the behaviours are expressed in the context of what questions and probes the teacher should provide for the children who are participants in the dialogue. The teacher should: elicit views and opinions; assist in clarification and ask for restatement; explicate student's views; seek consistency; request definitions; search for assumptions; indicate fallacies; request reasons; ask children how they know; and help children examine alternatives. Specific suggestions within each of these types of behaviours are given in Lipman *et al* (1980: 113–124).

A similar set of hallmarks are listed by Brown and Renshaw (1996) when defining Collective Argumentation. Collective Argumentation has as its ground rules: shared control of the content and direction of the discussion; shared establishment of common understanding; shared agreement about how evidence can be used; shared willingness to revise ideas when necessary; shared interest in progress of the discussion; shared construction of the mathematical knowledge; shared evaluation of the knowledge (p. 91).

As Brown and Renshaw (1996) note, these ground rules are similar to those Bereiter (1994) and Lampert (1990) had expressed for defining scientific and mathematical communities of discourse.

In a less teacher orientated view of classroom dialogue than that of Lipman *et al* is the view held by Splitter and Sharp (1995). They claim that dialogue, whether philosophical or not, has characteristics that make it distinct from both conversation and discussion, and suggest four conditions necessary for it to exist. (Although they describe the 'talk' of dialogue as 'conversation'!). These conditions are:

1. The conversation is structured by being focused on a single topic or question which is problematic or contestable.

2. The conversation is self-regulating or self correcting. Its participants are prepared both to question the views and reasons put forward by others, and to restate their own position in response to questions or counter-examples that come from the group.

3. The conversation has what we call an egalitarian structure. By what they say, participants show that they value themselves and one another equally for the purposes of the dialogue, irrespective of where they stand in relation to a particular viewpoint.

4. The conversation is guided by the mutual interests of its members. In a community of inquiry, it is the participants (of whom the teacher is but one) who set the agenda and determine the procedures for dealing with the issues at hand.

Splitter and Sharp (1995: 34-35)

These four conditions have been explicated by Splitter and Sharp in much greater detail, but the broad descriptions above encapsulate the essence of their view of dialogue.

While there are several views about the necessary conditions for dialogue, there is also considerable overlap in these views, and it is a reasonably straightforward process to become imbued with a holistic understanding of these conditions. That is to say, one can approach a video-taped episode (or its transcript) with sufficient understanding to tease out the talk and discover whether one has evidence of dialogue or not. While this methodology was not adopted in this particular instance, in the final analysis links were made from this video-taped episode back to such holistic understandings of what constitutes dialogue and its necessary ecological conditions.

What is scientific dialogue in the classroom ?

If one accepts that it is possible to distinguish dialogue from other forms of talk, then what remains is to tease out those aspects that make scientific dialogue in the classroom. Paul (1990) suggests that there is a critical thinking (via dialogue) approach to teaching science. This is 'concerned less with students accumulating undigested facts and scientific definitions and procedures, than with students learning to *think scientifically*. (p. 512) (Italics in the original). More specifically Lipman *et al* (1980) argue that science is concerned with theories about fact, and the questions raised are usually answerable, and a key feature of science is the discovering of evidence relevant to the question. Lipman *et al* also note that the presentation of scientific 'facts' in school science is contrary to scientific inquiry, and hides the evidence that these 'facts' rest upon.

Renshaw (1996) claims that 'In such [scientific] dialogues adults will expand the contributions of children, paraphrase, reinterpret, and substitute more general concepts for the children's everyday forms of speaking and acting.' (p. 62) while Paul (1990) suggests that '[w]henever possible students should be encouraged to express their ideas and try to convince each other to adopt them' (p. 515) as a way to teach science.

The American Association for the Advancement of Science (1996) claims that '[t]he various natural and social sciences differ ... in subject matter ... yet they share certain values, philosophical views about knowledge, and ways of learning about the world' (p. 7). It further recommends that students develop the 'values inherent in the practice of science, mathematics, and technology ... the use of

evidence and logical reasoning in making arguments; honesty, curiosity, and openness to new ideas; and skepticism in evaluating claims and arguments' (AAAS, 1996: 9).

Gaarder (1995), too, has suggested that the difference between science and other disciplines is in the nature of what is acceptable as proof (or indeed, refutation). I argue that the rôle of proof (and by extension, refutation) is critical in establishing the features and ecology of scientific dialogue.

The method of analysis

There were two courses of action possible: one was to identify the hallmarks of philosophical dialogue and then look for evidence of them within the episode, whilst the other was to identify those aspects of the episode that seemed 'different' and then see if these in any way matched the hallmarks of philosophical dialogue. As will become apparent, the second course was chosen, in the oft-heard sense of 'letting the data talk for themselves'.

Thus the approach was to tease out the threads of the talk in this video-taped episode, and look for features of this episode that appeared 'different' to those found in other instances of classroom talk, where 'different' was left, at this stage, somewhat undefined.

Once this had been accomplished, the selected 'differences' were categorised into mutually exclusive sets, and a description for each such set constructed. These category descriptions were then compared to the hallmarks of dialogue found in the literature. The set of hallmarks used were those of Splitter and Sharp (1995) listed above.

It must be remembered that the selection and categorization of parts of the talk in this video-taped episode are subjective; other researchers may select or categorise differently. I make no claim that either these results are unique or that they represent 'truth'; one must view the evidence and judge for oneself.

Features of the video-taped episode

The experiment that preceded the video-taped episode quite obviously gives a strong focus to everything that follows. Each of the children is involved, to varying degrees of course, to explaining the motion of the ball, and the unexpected results of their measuring. In the first example Stephanie is clearly attempting to explain what has happened.

> Stephanie: It's not really an idea it's an explanation why it's only 63 and that's 43. Because there it's not got a lot of gravity pulling it down but up there it's got quite a lot, so it's pulling it down a lot quicker, so it's gone a bit slow, so that'd be 63.

While she continues this, Daniel's interjection shows that he is following closely what Stephanie is saying.

Stephanie: Like from 43 it hasn't got as much gravity as it has from ...

Daniel: Yes it has, it's got exactly the same!

Stephanie: ... as from 95 to 190 because there it's not got as far for the gravity to pull it but up there it has got, so I think that's just about right.

In the third example, Richard who provides the least amount of talk in the video-taped episode, offers a key insight clearly based on thinking about the original question. The way in which the others agree with his observation point to the relevance of his comment.

Richard: The ball is speeding up as it's going down because it's got a longer time to speed up.

All: Yes!

Towards the end of the episode, Kelly introduces what at first hearing seems to be a red herring. However, it too, is strongly focused on the original problem as can be seen from her words quoted below.

Kelly: Well we go to rounders, some of us, and Mrs B always tells us to throw it straight so that it will speed up. She says not to throw it straight up because it'll take longer to come down. But it didn't in this case did it? Well it did, but it didn't take as long as we thought it would.

I believe that these examples show that the talk in this episode fulfils the condition that for dialogue the conversation needs to be 'focused on a single topic or question which is problematic or contestable' (Splitter and Sharp, 1995: 34). Further, there are few parts of the talk that could be deemed as not thus focused.

One striking aspect of the talk in this video-taped episode is the number of propositions made with some sort of supporting evidence or reason. The propositions may be refuted in the long term, but the fact that the proposition-with-evidence links are there makes this aspect of the talk quite unlike other classroom talk.

A key feature of these proposition-with-evidence links is the use of the word 'because'. The following illustrates this:

Kelly: Yes, it's about what Stephanie said. Well I don't think it's right because when people go to the moon and everything they don't say that gravity is different from the height. Like when one person stands on one foot it's not as much gravity pulling them down. Stephanie said that it's got more gravity than when it's up there, but I think that gravity is always the same.

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After this challenge to her original proposition, Stephanie introduces her new proposition about how gravity acts, again linking her proposition with evidence through the use of 'because'.

Stephanie: The gravity's the same all the time, but from up there the gravity's got more of a chance of pulling it. But from there it's got less chance because it's falling down.

[...]

Stephanie: No, like I say the gravity isn't different. It's because up there it's got more time to pull it. From there it's got hardly any time to pull it, because it's going down. So it's not the gravity that's different.

The following, however, shows a variation on the proposition-with-evidence link, with Richard's 'evidence' being an analogy. It receives support from Kelly, who is able to extend the analogy:

Richard: I think it'll go faster downwards if you lift it higher up because it's like someone running, they've got to get a further run up to speed up and that's [the ball is] speeding up.

[Julian prompts him to repeat his idea.]

Richard: The ball is speeding up as it's going down because it's got a longer time to speed up.

[...]

Kelly: That's good, that!

[...]

Kelly: Well it's like I didn't think about speeding up, or anything. Like when Richard says that, when you come to think of it, you don't just stay the same speed all the time, like if you're in a race you don't just stay the same speed.

These children are able to provide reasons for the propositions that they put forward, and also to challenge, or add to, propositions of the others, and to alter their position in response to challenges from the group.

Within the talk in this video-taped episode there are many comments made that I believe indicate that the participants, including Julian the adult, are listening attentively to one another. This is shown when comments are made that either build upon a previous remark, or when a counter-proposition is put. In the following example, Julian is attempting to clarify in his mind what the previous comments mean:

Julian: You said a lot of interesting things there, but I need to take it a bit slower. What's gravity doing?

When Daniel suggests a method for removing any inconsistency by the person

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dropping the ball (and thus altering the time taken to fall) he, Kelly and Julian have the following inter-change.

Daniel: But different if the person letting go of the ball might be letting go of it different every time. So it might have a different effect on it. So it'd be easier if we could get something to do the letting go of the ball for us, the same every time. But we haven't got much equipment, like.

[...]

Kelly: I've got an idea for what Daniel said: that we need something to drop it. If we tied the ball with a bit of string and we tied it to the pipe and tie it round the tin and we put the ball in. Oh no, that wouldn't be right because of if you use energy ... losing energy ...

Daniel: You'd be losing energy all the time.

Julian: You want to make sure someone isn't throwing it or holding on to it when they let go all. Yes .... That could-be something that we might do something about in this practical, we might be able to fix it up so we get more consistent, I suppose that's the right word, ways to drop it.

Some inter-changes are attempts by the group to counter earlier explanations and clarify the current position. In the following example Stephanie's ideas are rejected and she is allowed to change her mind with dignity.

Richard: I think that gravity 's got to be the same.

Julian: Gravity's the same everywhere. And Stephanie agrees with that.

Kelly: But, the way she was saying the explanation before it sounded like the gravity was different.

Daniel: She did mean that, before.

Stephanie: No, it's got more chance of pulling it.

Daniel: You said there's more gravity when it's higher than when it's lower. That's what you said.

Stephanie: Oh yes, right.

[Daniel and Stephanie laugh.]

Later, Julian and Kelly provide a further example of members of the group using the arguments and propositions provided by others. Julian asks Kelly whether she agrees with Richard's explanation of why the ball speeds up. She agrees with his explanation and adds her support to Stephanie's proposition that the falling ball's motion is similar to that of a rolling ball (an earlier practical experiment done by the group).

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Julian: Why is that a good explanation, Kelly? Does that explain it?

[Kelly nods her agreement.]

Julian: Why?

[...]

Kelly: I don't understand but I know the connection — the ball speeded up as it was going along and that [the timer-ball] speeded up as it was going down!

I believe that these examples show members of a group who listen to one another's ideas, and use these to further the group's efforts to solve the original problem. Everyone has the same 'speaking rights' except perhaps Julian. Julian, however, is careful not to take a dominant rôle, and so the children in the group 'value themselves and one another equally for the purposes of the dialogue, irrespective of where they stand in relation to a particular viewpoint' to use Splitter and Sharp's phrase (1995: 35).

While I believe that this video-taped episode has features not found in other classroom episodes, it is true that the rôle of the teacher, Julian, is more conventional than these other aspects. Clearly he is managing the flow of the talk, both in who speaks and in the direction taken by the content. For example, in the following exchange, Julian summarizes the position so far and encourages Daniel to put his explanation of the group's data.

Julian: We had .43 from this height, then we went for double the height, another 95, and we got about .63. And Richard's explanation was it's gone all the way round in ten seconds and come back to the beginning again. And you were going to say Daniel?

Daniel: I think it's quite good because we was planning to get 60, um 86, so that's 20, 23 away which means that we should have gone a bit higher but we measured, we doubled it, but from here it doesn't look the same length from the 43 downwards.

Julian: So you think the girls made a mistake when they measured the 95.

Daniel: Yeah when they measured it, yeah.

Julian: That's a good explanation if it's true, that they might have measured it wrong.

The data and Richard's explanation are summarized and then Daniel is given the opportunity to speak. His ideas are supported by Julian, but not unreservedly; there is room left for a challenge, one that Kelly takes up.

The direction in which the talk goes is also strongly directed by Julian; this is managed by the way in which he focuses and selects the ideas that he wants pursued further. Here is a typical example:

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Julian: But I'm still interested in Stephanie's idea that the gravity is pulling it. Is it that gravity's pulling it quicker or ...?

Stephanie: The gravity's the same all the time, but from up there the gravity's got more of a chance of pulling it. But from there it's got less chance because it's falling down.

There are more such instances throughout the video-taped episode, but never as many, I would argue, as in the 'discussions' quoted in the literature. Another feature that is evident in this episode is that Julian seeks further evidence and extended reasons for propositions put by the children in the group. The following is a simple example of this.

Stephanie: It's pulling it down.

Julian: And what's that got to do with it?

This, on the other hand, is a longer example:

Julian: Richard, what do you think ?

[...]

Julian: Say that again, what's speeding up?

Richard: The ball is speeding up as it's going down because it's got a longer time to speed up.

All: Yes.

[...]

Julian: It's like someone sprinting — it takes a while to get up to speed. And you think that's what's happening to the ball?

[...]

Richard: Yes, you can't just set off like that.

[He shows it with his hand.]

[...]

Julian: So the ball's changing it's speed. So how does that explain what we found?

In this video-taped episode it is apparent that one of the ground rules is that group members must attend to one another's ideas. Julian is well aware that this sustains the flow of the talk, and constantly reminds the group of the rule as is shown by the following examples.

[Kelly has her hand up.]

Julian: Did you really listen to what she said Kelly? You know what I say when people put their hand up and don't listen when somebody's explaining.

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Kelly: Yes, it's about what Stephanie said.

And further:

Julian: Right, I think Daniel's going to say something first, and then Stephanie's going to defend herself and then we're going to ask Richard what he thinks in a minute.

[...]

Julian: And you want to add to that. But you were listening to what he was saying though? Right, Stephanie, then Kelly.

The rôle played by the adult, or teacher, is critical in determining the extent to which one may say that the children 'determine the procedures for dealing with the issues at hand' (Splitter and Sharp, 1995: 35). The evidence from this video-taped episode would suggest that whilst there is a feeling of an overall 'balance of power', the reality is that Julian is in control. However, I believe that he displays more of Splitter and Sharp's (1995) 'scholarly ignorance' than most adults in similar situations.

What have I learned from this episode?

The following paragraphs summarise my observations after studying the video-taped episode and attempting to categorize and describe what I believe are its critical aspects. I believe that these convey the essence of the ecology apparent to any observer. Again I would point out that the ecology of the dialogue is defined as those behaviours (of the participants) and the features (of the interactions) that sustain, expand, and guide the dialogue.

A striking feature of a small group dialogue, as presented in this video-taped episode, is how like woven fabric it is. The conversation of each group member weaves through and around that of the others, all the while extending and strengthening the whole; and like a fabric, dialogue needs to be crafted, rather than left to chance. This, I believe, suggests that teachers can play a key part in the development of children's science through dialogue. I certainly would agree with Renshaw (1996) that'[d]ialogues between adults and children reveal some of the characteristics of the more mature concepts ... [which] creates tension in children's thinking, and the social conditions conducive for development. (p. 62).

That the children had all shared the experience of watching, dropping, and measuring the timer-ball and its fall meant that the problematic (describing the motion of the ball) provided a vivid focus for their dialogue. The children were involved in answering a 'real' question, but a question whose answer was neither clear nor simple. The group started with two quite different explanations for the measurements obtained; either that they were incorrectly taken, or gravity effected the speed of the ball. The situation just described is not unlike that occurring in many science classes, but what follows is not so

common. Noticeably these children exhibit a singular difference to many other groups involved in science 'discussions'. This is that propositions and alternative explanations are supported by reasons; the commonly heard phrase (or a paraphrase of it) is 'I think that ... because ...'. The focus is upon explaining why, a crucial feature of the ecology here.

A key aspect of the ecology of this dialogue is the equality that is evident in the relations between the participants. All viewpoints are listened to and accepted as having merit, although not necessarily believed to be true. At no time do we feel that

> There are lots of people who are always asking things ...
> And I know they'll think me silly if I get the answer wrong.
>
> *The Friend*, A. A. Milne

Julian, the adult, shows much of the 'scholarly ignorance' demanded of teachers by Splitter and Sharp (1995) in the dialogues of a mature community of inquiry. Having said this, it is clear that the teacher has more status in this group than the children by the way he takes on the rôle of discourse guide, the weaver of the fabric of the dialogue. Although the rôles of the individual participants in the dialogue of a mature 'community of inquiry' are equal, in this video-taped episode we see a community not yet mature, in this sense, but moving towards that state. Some aspects of the teacher's rôle have been described earlier, but there are four key aspects to the teacher's place in the dialogue's ecology visible in this video-taped episode. This teacher *encourages* the group to listen to other opinions and to reasons in support of propositions. He *focuses* attention on what appear to be productive lines of thinking. There is his *summarising* of the dialogue so far, and finally there is the *validation* of children's ideas that can help the dialogue progress.

Possibilities and problems

This video-taped episode clearly demonstrates that scientific dialogue is possible with groups of children if the ecology is right. This is not to say that the video-taped episode represents a mature dialogue in full swing; clearly it is not. I believe that the greatest difference between this small group demonstration and full classroom implementation is nothing other than establishing the ecology. The question is: What *is* this ecology? The answer can be found in the ground rules that would appear to guide the dialogue in this video-taped episode.

On the basis of this video-taped episode, the conditions that seem necessary for dialogue to exist within the classroom are respect for others' points of view, the provision of supporting evidence for propositions offered, and a problem that has no trite answer, but promotes uncertainty. If one adds to that a 'weaver' to guide the process, then a fabric of distinction is possible.

The analysis of the video-taped episode has provided a small set of 'rules' that are remarkably similar to those endorsed by authors from many disciplines, from mathematics to philosophy. This is no coincidence; a mature dialogue is a goal that many desire. In practice, we have found it extremely difficult to achieve genuine dialogue in the classrooms in which we are working. Perhaps understanding the ecology and its necessary conditions may remedy the situation.

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